REMARKS/ARGUMENTS

In the Office Action dated June 15, 2004, the Examiner objected to the specification and the drawings in paragraphs 3 on page 2. The specification is amended in accordance with the Examiner's suggestions. Applicants thank the Examiner for the suggestions.

Note that in the attached set of replacement drawings, the following reference numerals have been removed: 90 from FIG. 1A, 103M from FIG. 1B, 140 from FIG. 2A, and 170 from FIG. 2B. Furthermore, FIG. 3C is amended to change reference number 300 to identify the dashed box and to change reference number 320 to identify the device containing the laser, and change reference number 324 to identify the closest box on its right. The just-described changes to FIG. 3C are supported throughout the originally-filed specification, including, for example, page 23, lines 8-13. Finally, FIG. 3D is amended to change the rectangular shape of boxes labeled as 358 and 359 to a traditional diamond shape as illustrated by box 60 in FIG. 1A.

Moreover the specification has been amended as shown above to insert appropriate reference numerals. Applicants submit that the amendments to the specification are supported throughout the originally-filed application. For example, reference numeral 105 is inserted at originally-filed page 9 line 28 to identify unpolished wafers. As seen from originally-filed FIG. 1B, the reference numeral points to a wafer that is yet to enter the chemical mechanical polisher 102 and hence it is unpolished. As another example, the specification is amended at page 18 to identify the lines 107 and 108 shown in FIG. 1B as carrying control signals to items 101 and 102. Item 101 is shown in FIG. 1B as containing the layer formation apparatus, and item 102 is shown as the chemical mechanical polisher.

Finally, note that a new sentence is added at the end of the paragraph in the originally-filed text at page 19, line 23. This sentence is supported by the words in box 175 shown in originally-filed drawing FIG. 2B.

In view of the above amendments and remarks, Applicants respectfully request the Examiner to withdraw the objection to the specification and to the drawings.

To further prosecution as quickly as possible, Applicants have canceled a number of claims, while reserving the right to prosecute the canceled claims in a continuation application in future.

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Applicants believe that Claim 39 was improperly rejected in the above-identified Office Action at paragraph 9 on page 6, as being obvious over Nikoonahad's US Patent 6,694,284 when viewed with evidence of Wang's US Patent 6,734,968 and further in view of applicants' own disclosure of prior art. Specifically, the Examiner's remarks on page 9 regarding Claim 39 did not cite a column and line where Nikoonahad discloses use of a white light source.

But, the Examiner did state at the bottom of page 4 (in explaining the rejection of Claim 15) that in FIG. 5 of US Patent 6,694,284, Nikoonahad suggests his system could comprise a combination of a reflectometer of single wavelength and a broadband, spectroscopic reflectometer (column 9, lines 10-20). The language cited by the Examiner is reproduced below:

> In an embodiment, the measurement device may include a non-imaging scatterometer, a scatterometer, a spectroscopic scatterometer, a reflectometer, a spectroscopic reflectometer, an ellipsometer, a spectroscopic ellipsometer, a beam profile ellipsometer, a dual beam spectrophotometer, a bright field imaging device, a dark field imaging device, a bright field and dark field imaging device, a bright field and/or dark field non-imaging device, a coherence probe microscope, an interference microscope, an optical profilometer, or any combination thereof. See US Patent 6,694,284 at column 9, lines 10-20.

Applicants submit that the above-quoted text provides no indication whatsoever as to how measurements from a broadband spectroscopic reflectometer are to be combined with a measurement from a single wavelength reflectometer.

In rejecting Claim 39, the Examiner further stated at the bottom of page 6 of the Office Action that "models of reflectance are produced at several wavelengths for critical dimensions and subsequently, models using predetermined amounts such as offsets are used (col. 43, lines 45-67; col. 44, lines 1-5; col. 45, lines 35-40; col. 60, lines 20-45; col. 154, lines 5-11)." Nikoonahad's language cited by the Examiner is reproduced below:

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> The photodiode array, therefore, may measure the reflectance spectrum 92 of the light returned from the surface of the specimen. A relative reflectance spectrum may be obtained by dividing the intensity of the returned light of the reflectance spectrum at each wavelength by a relative

reference intensity at each wavelength. A relative reflectance spectrum may be used to determine the thickness of various films on the wafer. In addition, the reflectance at a single wavelength and the refractive index of the film may also be determined from the relative reflectance spectrum. Furthermore, a model method by modal expansion ("MMME") model 94 may be used to generate library 96 of various reflectance spectrums. The MMME model is a rigorous diffraction model that may be used to calculate the theoretical diffracted light "fingerprint" from each grating in the parameter space. Alternative models may also be used to calculate the theoretical diffracted light, however, including, but not limited to, a rigorous coupling waveguide analysis ("RCWA") model. The measured reflectance spectrum 92 may be fitted to a the various reflectance spectrums in library 96. The fitted data 97 may be used to determine critical dimension 95 such as a lateral dimension, a height, and a sidewall angle of a feature on the surface of a specimen as described herein. See US Patent 6,694,284 at column 43, line 45 to column 44, line 5.

For example, a relative reflectance spectrum may be obtained by dividing the intensity of the returned light at each wavelength measured by spectrometer 128 by a relative reference intensity at each wavelength measured by reference spectrometer 110 of the measurement device. The relative reflectance spectrum may be fitted to a theoretical model of the data such that a critical dimension, a height, and a sidewall angle may be determined. See US Patent 6,694,284 at column 45, lines 35-40.

In addition, a system as described herein may be configured to adjust a drifting process mean to a target value and to reduce variance in critical dimension distribution of features on a specimen by accounting for autocorrelation in the critical dimension data. For example, the critical dimension distribution of features on a specimen after a develop process step may be reduced by altering a parameter of an instrument coupled to an exposure tool or a develop process chamber. Such an altered parameter may include, but is not limited to, an exposure dose of an exposure process or a develop time of a develop process. In addition, a linear model of control may be used and only the offset terms may be updated or adapted. A linear model of control may include a control function such as: y=Ax+c, where A and c are experimentally or theoretically determined control parameters, x is a critical dimension of the specimen or another such determined property of the specimen, and y is a parameter of an instrument coupled to the semiconductor fabrication process tool. Alternatively, a parameter of an instrument coupled to a semiconductor fabrication tool such as the exposure tool may be altered by using an exponentially weighted moving average of the offset terms. A proportional and integral model of control may include a control function such as: $c_t = \alpha E_{t\text{-}del} + (1-\alpha)c_{t-1}$, wherein α is an experimentally or theoretically determined control parameter, $E_{t\text{-}del}$ is a determined property

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of the specimen, and c_t is a parameter of an instrument coupled to the semiconductor fabrication process tool. See US Patent 6,694,284 at column 60, lines 19-46.

Appropriate mathematical models may include any mathematical models known in the art such as mathematical models that may be used to determine a critical dimension of a feature. The mathematical models may be configured to process data of multiple wavelengths or data of a single wavelength. See US Patent 6,694,284 at column 154, lines 6-11.

Applicants submit that the above description pertains to Nikoonahad's use of spectral reflectance to measure critical dimensions of a structure (such as line width, line height, and sidewall slope), but not to measure **thickness of a top layer** as recited in Claim 39. The word "top" has been added to Claim 39, and use of this word is supported throughout the originally-filed specification, including, for example, page 7 line 5, page 11 line 18 and page 25 lines 18 and 21. In contrast, a skilled artisan reading Nikoonahad's description would be directed to measuring critical dimensions of patterned structures, and there appears to be no suggestion or motivation to lead the skilled artisan into measuring layer thickness as per Claim 39.

Furthermore, Applicants respectfully submit that the above-quoted text from Nikoonahad's patent does not support the Examiner's position. At most the above-quoted text teaches that a measured reflectance spectrum may be fitted to one of several reflectance spectrums that are already present in a library, and then the fitted data is used (apparently without any further measurements), to determine a critical dimension (which is not the top layer's thickness). Note that the conventional use of the term "critical dimension" is a dimension (such as width, slope, depth) of a patterned structure such as a metal line or a trench etched in a dielectric. This term is not conventionally used in the context of layer parameters such as thickness of a dielectric coating.

In contrast, it is not sufficient, as per originally-filed Claim 39, to determine a critical dimension, from a fitted spectrum that is obtained from a set of measurements at **multiple wavelengths** as per Nikoonahad's description. Instead, Claim 39 requires that such multiple measurements be used to create a model of reflectance at a single pre-selected wavelength to be used later, as a function of layer thickness. Claim 39 further requires that a beam of the pre-selected wavelength be used in making an additional

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measurement, followed by use of the created model with the **single wavelength** additional measurement, to determine layer thickness. Note that Claim 39's model provides calibration for the additional measurement which is used to determine layer thickness (at the location where the additional measurement is made).

Note that use of a single wavelength beam of the type described above has several advantages, including, the following. A single wavelength beam can be made into a very small spot, smaller than a beam having multiple wavelengths. Therefore, in many applications (e.g. polishing control), a method covered by Claim 39 can take advantage of the need to know only one parameter – thickness of the top layer – to minimize the spot size.

In this context, Applicants respectfully draw the Examiner's attention to the language at column 67, lines 30-49 and column 73 lines 40-56 in US Patent 6,694,284, which is reproduced below (with emphasis added):

> In a further embodiment, the processor may be configured to generate a database. The database may include a set of data that may include at least first and second properties of a specimen. The processor may be also be configured to calibrate the measurement device using the database. For example, the set of data may include at least a first and second property of a reference specimen. The measurement device may be configured to determine the first and second properties of the reference specimen. In this manner, the processor may be configured to calibrate the measurement device by comparing the first and second properties of the reference specimen in the database and the determined first and second properties of the reference specimen. For example, the processor may be configured to determine a correction factor from the comparison of the first and second properties in the database and the determined first and second properties of the reference specimen. **In addition, the processor may be configured to use the correction factor to determine first and second properties of additional specimens.**

> In an additional embodiment, the method may include generating a database. The database may include at least two determined properties of a specimen. The method may also include calibrating the measurement device using the database. For example, the database may include at least a first and second property of a reference specimen. In addition, the method may include determining the first and second properties of the reference specimen with the measurement device. In this manner, the method may include calibrating the measurement device by comparing at least one of the properties of the reference specimen in the database and

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> at least one of the properties of the reference specimen determined with the measurement device. **For example, the method may include determining a correction factor from the comparison of at least one property of the reference specimen and using the correction factor to determine at least the first and second properties of additional specimens.**

Note that the emphasized text in the above-quoted Nikoonahad's description makes it clear that a measurement is made on a reference specimen which is then used as a calibration for measurements on additional samples. In contrast, in Claim 39, calibration data is generated on the same workpiece on which a final measurement is made.

Nikoonahad's description is unclear about what measurements are made, how a calibration is created, and whether the calibration is simply a result of the correlation between two measurements. Applicants submit that Nikoonahad is describing establishing an empirical calibration for a first and second measurement based on values taken from a reference sample and stored in a database (in the first paragraph quoted above), or determining a correction factor to the database values based on measurements taken on a reference sample. This would be a method to correct for drift in a measurement tool, where the measurement tool slowly drifts from reference values stored in a database. Applicants submit that Nikoonahad is not describing the taking of a single reference measurement (reflectance spectrum) at a site on the same workpiece as a measurement site, developing a calibration measurement, and taking a second measurement on the same workpiece with calibration based on the reference measurement.

In contrast, Claim 39 uses the measurements at multiple wavelengths on a single workpiece to develop calibration data for use in interpreting the result of an additional measurement on that same single work piece, using a predetermined wavelength beam.

Applicants further note that Claim 39 also distinguishes over a calibration ellipsometer that is disclosed in US Patent 6,694,284 at column 107, line 66 to column 108, line 20. It appears that Nikoonahead has a second ellipsometer for reference calibration, both devices measuring the same sample to determine drifts in order to calibrate the measurement ellipsometer. This does not suggest the use of a reference measurement to calibrate a second measurement at a different site on the same wafer.

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Furthermore, Wang appears to discuss use of a polarimiter to improve performance of a spectroscopic ellipsometer.

For the above reasons, Applicants respectfully request allowance of Claim 39 as well as all claims that depend therefrom. Should the Examiner have any questions concerning this response, the Examiner is invited to call the undersigned at (408) 982-8200, ext. 3.

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Respectfully submitted,

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Amendments to the Drawings:

In the attached sheets of drawings, the following changes have been made.

In FIG. 1A, reference number 90 is removed.

In FIG. 1B, reference number 103M is removed.

In FIG. 2A, reference number 140 is removed.

In FIG. 2B, reference number 170 is removed.

In FIG. 3C, reference number 300 is changed to identify the dashed box, and reference number 320 identifies the device containing the laser, and reference number 324 identifies the closest box on its right.

In FIG. 3D, the rectangular boxes identified by reference numbers 358 and 359 are replaced with diamond boxes.

Attachment: Eleven (11) Replacement Sheets

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